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EXOTIC WOODS FOR BRIDGES

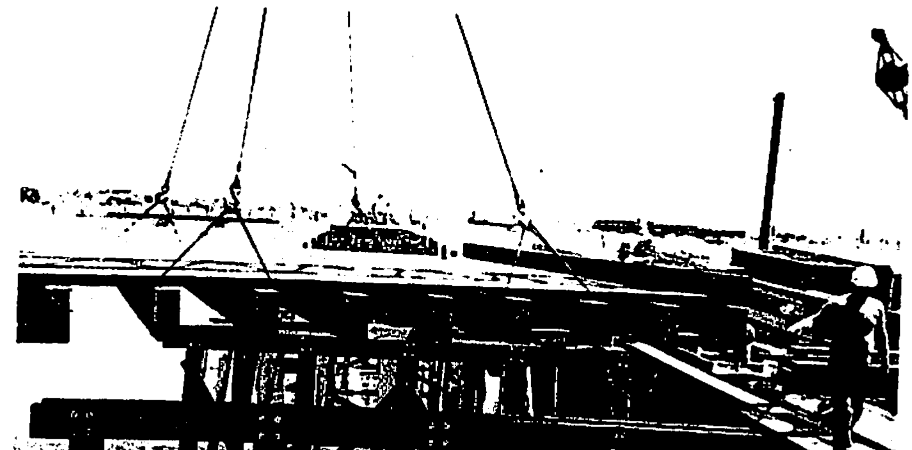
foreign jungle woods so dense they do not float, so tough that they do not rot, may be cost-effective for certain spans, says engineer

Exotic woods imported from the jungles of Africa and South America may offer a cost-effective alternative to steel, concrete or even pressure-treated domestic wood in the construction of certain bridges, according to an award-winning Massachusetts professional engineer.

Thomas R. Parello, chief engineer for the New England regional office of consultants Gannett Fleming of Braintree, and a former vice president of Boston consultants Universal Engineering Corporation, pointed out the advantages of using exotic species in a recent interview with New England Construction. Parello designed the Duxbury, Massachusetts bridge which received national recognition and won an excellence award from the New England section of the American Consulting Engineers Council two years ago when he was a vice president at Universal.

Since exotic woods have been used only sparingly in this country and never before on a project of this magnitude, Parello became an acknowledged expert on the subject while researching engineering literature for his design. The 2200-foot-long bridge linking the mainland with a barrier beach is the longest in the U.S. to be built of exotic woods, and the engineer has been in demand to speak before professional groups of his experience, most recently, at a structural group meeting of the Boston Society of Civil Engineers (BSCE).

Parello said that engineers should consider using the imported species instead of traditional materials in some circumstances where, for example, costs, aesthetics or environmental impact are key concerns. On structures requiring relatively low-bearing capacity, timber construction may be significantly cheaper than steel, cast-in-place concrete or precast concrete, and may produce a more pleasing visual effect, he said. And if exotic woods are used, he noted, the long-term costs may be lower, and the environmental impact less, than those associated with pressure-treated domestic woods. Citing the two species imported by the Fortek Company for use at Dux- ➤



Harbor Marine crew lowers prefabricated panel made of West African wood on bents supported by South American piles, for Duxbury, Mass. bridge.

By Paul Fournier
Associate Editor

bury — Angelique from Guyana, South America, and Ekki from West Africa — Parello said that the flexural, or bending, strength used for design calculations is 3700 pounds per square inch, roughly three times as great as that of Southern Yellow Pine (SYP), the domestic softwood most frequently used when pressure-treated wood is required in construction. So dense they will not float in water, the imported woods weigh approximately 70 pounds per cubic foot, about 50 percent more than SYP, and are almost impervious to marine boring animals which can eventually damage even pressure-treated domestic wood when used in salt water.

Thomas R. Parello, P.E., advocates use of tough imported woods on some bridge spans as a cheaper alternative to steel, concrete or pressure-treated domestic wood.

The 2200-foot structure linking mainland with barrier beach in Duxbury, is longest U.S. bridge made of exotic woods. (Photo by Robert Arruda)

Of increasing concern, too, he said, is the possible adverse effects of chemicals leaching out from the pressure-treated wood into the environment.

On the down side, Parello said that using exotic woods sometimes sparks a knee-jerk response from so-called environmentalists. At Duxbury, bales of the imported timbers were defaced with white paint and graffiti crying "Save the rain forests."

"The protesters were misguided and the damage unwarranted," said Parello. "These timbers came to us from government-controlled harvesting operations for the purpose of manufacturing a construction product. They weren't the result of wholesale, indiscriminate 'slash-and-burn' tree clearing made for the purpose of developing farm land."

Vandals in the night also tossed some of the bales of wood into the ocean, probably with the expectation that the timbers would be carried out to sea, said Parello. However, they simply sank to the ocean bottom, and the contractor retrieved the structural members the next day using divers and a crane.

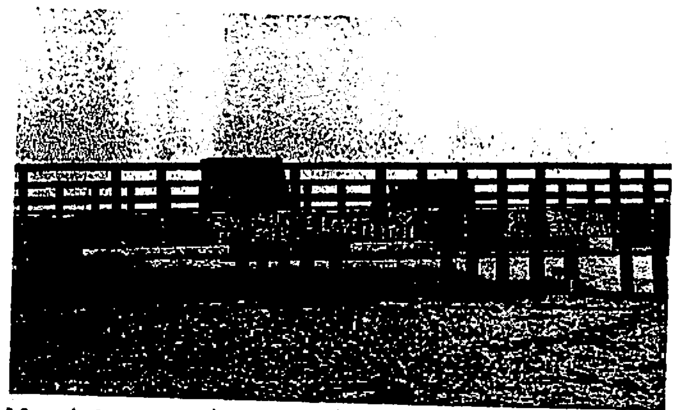
Universal Engineering has had experience with exotic species on other bridge projects. One, a 320-foot-long bridge joining a small island to the mainland in Westport, Connecticut, used a species called Greenheart. Similar to Angelique, it was used at the time because Guyana, the source of Angeliqué, was in the throes of a revolution that interrupted production. Employed at Universal at the time, Parello reviewed and approved the design of the bridge, which was prepared by Hacon Company, the supplier of the wood. The Boston consultants have more recently used Ekki for the railing of a bridge over the Charles River linking Newton and Needham, Massachusetts, according to Martin Roche, one of two resident engineers employed by Universal during the construction of the Duxbury bridge.

Speaking at the recent BSCE meeting, Parello recounted the details of the Duxbury bridge project:

The new structure replaced a badly deteriorated Powder Point Bridge, a landmark said to be the longest wooden bridge in the United States. It was finally closed by the Massachusetts Department of Public Works after a fire truck, responding to a fire on the bridge, broke through the ➤

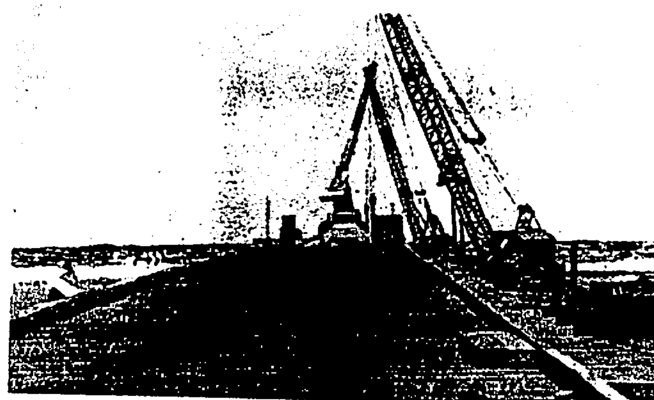
Powder Point Bridge

Untreated exotic woods are expected to last at least 50 years, far longer than these piles made of domestic softwood.



Vandals protesting use of exotic woods by defacing bridge were mistaken says engineer, noting that timbers were not product of "slash-and-burn."

Subcontractor Lindberg Marine tows barge full of prefab deck panels to job site.



Harbor Marine's barge-mounted #703 Lima and #1005 Koehring cranes offload prefab sections while a small Pettibone rough terrain crane works with carpentry crew.

deck. Since the closing forced Duxbury residents to detour about seven miles in order to get to the popular barrier beach, town officials wanted to place the bridge back in service as soon as possible. Universal was selected to make an engineering evaluation of the existing bridge to determine the extent of the damage and possible remedies. The engineer concluded that the cost of rehabilitating the bridge would have been prohibitive, and its rated capacity could not be upgraded with simple rehab work. Building a new bridge of steel or concrete with a desirable 15-ton bearing capacity was estimated to cost about $4 million, while the price tag for a similarly strong timber replacement of exotic wood or SYP treated with chromated copper arsenate was figured at approximately $3 million. The initial cost for the treated wood was slightly lower, said Parello, but since it is not expected to do as well in the harsh salt water environment — a longevity of 30 years compared with at least 50 for the exotic species — the maintenance and repair costs would make the treated wood alternative the more expensive in the long run. What's more, with exotic wood construction, there is no danger of chemicals leaching out, he said. And town residents liked the idea of having a wood bridge for aesthetic reasons. The decision was made, and the bridge put out to bid.

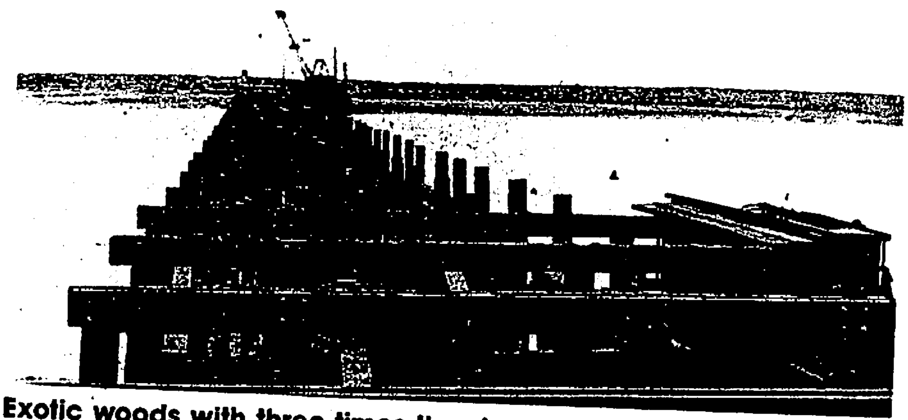
Contractor Harbor Marine of Warwick, Rhode Island won the job and began construction in late 1986.

The old bridge had been constructed of more than 1000 round piles, with bents consisting of five piles tied together through double 4x14's and capped by a single 4x14. Spaced 16½-feet apart, the bents supported 6x14 longitudinal stringers placed at 24-inch intervals, which in turn held the 4x10 deck planks. Originally, the piles had all been white oak but were replaced over the years with SYP, the newer ones being pressure-treated. In contrast, the new bridge features bents of five, square-cut piles of Angelique, spaced at 20-foot intervals, with the longer 20-foot stringers spaced 27 inches apart, and a deck of 3x10s. The stronger exotic wood allowed the use of greater spans, almost 500 fewer piles, and a lighter deck, yet the new structure will support 15 tons compared to the four-ton capacity of the old bridge. In addition, the new bridge has a 20-foot-wide roadway and five-foot sidewalk, compared to 18-and 4-foot for the old structure.

Piles used for the project were made of hand-hewn Angelique that were shipped to various ports in the U.S. and Canada and trucked to Duxbury. Harbor Marine fashioned a steel template for driving two bays, or three bents, of piles, at a time, leaving the old piles in place to support the driving operation. The contractor employed a vibratory hammer to drive the friction piles for most of ➤

their lengths, which in some cases were 50 feet, then a pneumatic hammer for the last foot to enable engineers to verify capacity by counting blows and using the ENR Formula. The new piles are each rated at 30-ton capacity, while the old ones had a 10-to 12-ton rating. Once three successive bents were driven, crews moved the template to the next station, extracted the old piles, and repeated the operation.

In the meantime, a factory in Holland had milled every piece of timber required for construction to correct size, and shipped the pieces to subcontractor Lindberg Marine Inc. of Fairhaven, Massachusetts, who assembled 20-foot by 20-foot deck panels for the roadway complete with stringers and planks. The prefabricated units were then barged to Duxbury where Harbor Marine's barge-mounted crane offloaded them for the carpenter crew. Workers next fastened the panels to the bents.



Exotic woods with three times the strength of southern yellow pine allowed use of fewer piles and longer spans between bents while yielding greater bridge-carrying capacity.

Fasteners were either high-strength bolts, used in connecting double-beam caps to the piles to form bents, or steel pins, force-fitted through pre-drilled holes, used for most of the superstructure. At the contractor's request, the engineer allowed the predrilling of the holes at the factory, to ease field-drilling of the extraordinarily tough wood, but required that the pre-drilled holes be ⅛th of an inch smaller in diameter than the finished field holes. The finished holes were $\frac{1}{16}$th of an inch smaller than the pin diameters to ensure a tight fit.

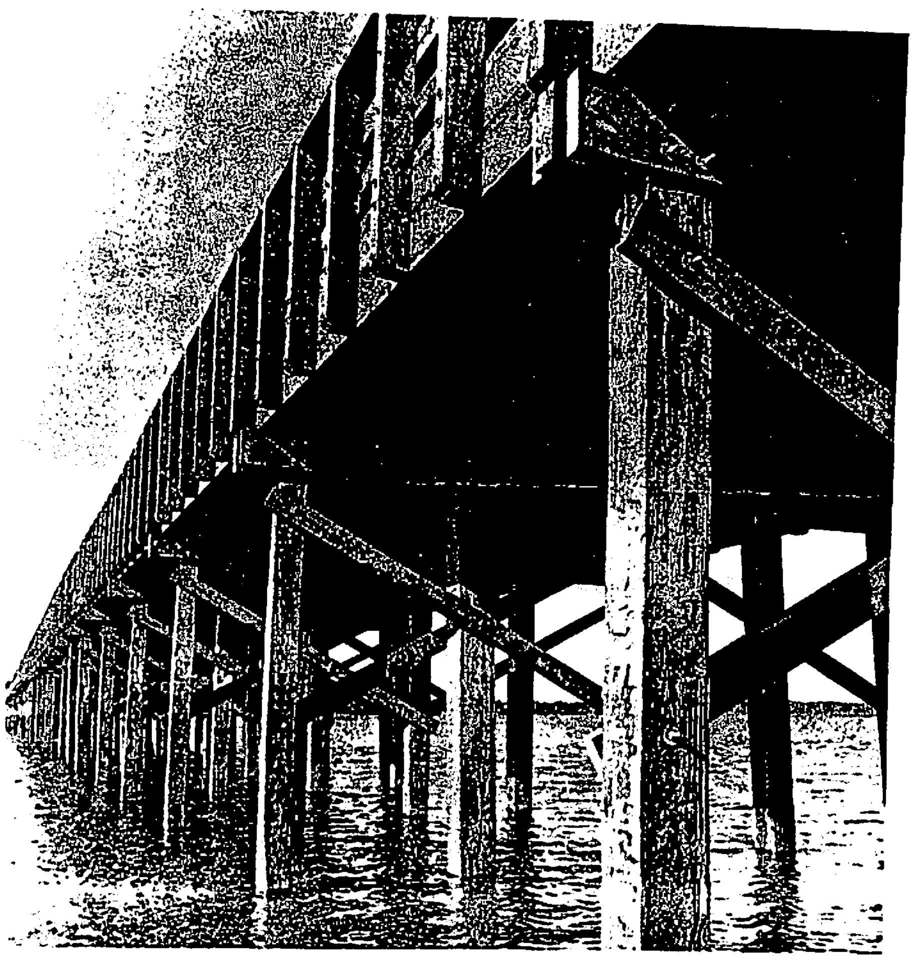
"The wood does shrink when it dries," he said, "and when this happens, the holes can become oval." This would have jeopardized the connections. Prefabrication was specified in the contract to speed the job, since panels could be assembled inside a shop, regardless of weather, to more exacting standards than stick-built construction would allow. It also precluded much of the impact that any type of field construction has on the environment. To make sure the bridge components all fit together properly, the contractor hired consultants Simpson Gumpertz and Hager to convert Universal's engineering drawings into shop drawings with every single timber of the bridge assigned a coded number. The fabricators and the contractor relied on these codes to make sure everything came together the way it was supposed to.

In the end, they did. And at a remarkably fast pace, said Parello.

"The contractor had no prior experience with this type of wood, but he did an excellent job. So did the suppliers and everyone else concerned with this project.

"From the time we made the initial assessment of the condition of the old bridge, to the opening ceremony for the new one in August of '87, only 20 months had passed.

"That has got to be some kind of a record, no matter what the bridge is made of." ■



Finished bridge, with hand-hewn Angelique piles supporting superstructure made of prefab panels of Ekki wood, has carrying capacity of 15 tons, compared to six tons for original bridge when it was in its prime. (Photo by Robert Arruda)